Microlens Array/Pinhole Mask to Suppress Starlight for Direct Exoplanet Detection

Completed Technology Project (2017 - 2019)

Project Introduction

Direct imaging of habitable exoplanets is a key priority of NASA's Astrophysics roadmap, “Enduring Quests, Daring Visions." A coronagraphic starlight suppression system situated on a large space telescope offers a viable path to achieving this goal. This type of instrument is central to both the LUVOIR and HabEx mission concepts currently under study for the 2020 Decadal Survey. To directly image an Earth-like exoplanet, an instrument must be sensitive to objects ten billion times dimmer than their parent star. Advanced coronagraphs are designed to modify the shape of the star's image so that it does not overwhelm the planet's light. Coronagraphs are complex to design and fabricate, tend to sacrifice a significant portion of the exoplanet light entering the telescope, and are highly sensitive to errors in the telescope. The proposed work reduces the demands on the coronagraph and its sensitivity to errors in the telescope, by changing how we implement optics in the spectrograph following the coronagraph. Through optical analysis and modeling, we have found that a microlens array with a specially arranged pattern of pinholes can suppress residual starlight in the scientific image after the coronagraph by more than two orders of magnitude. This added layer of starlight rejection could be used to relax the extreme observatory stability requirements for exo-Earth imaging applications, for example shifting the wavefront stability requirement from a few picometers to a few nanometers. Ultimately this translates to the instrument detecting and spectrally characterizing more exoplanets than a conventional coronagraph system. This microlens/pinhole concept is also compatible with starshade-based starlight suppression systems. The proposed microlens/pinhole device is entirely passive and augments the performance of existing coronagraph designs, while potentially reducing their cost and risk for mission implementation. Our APRA proposal would support a testbed demonstration of this novel concept. Our plan is to design and procure the combined microlens-pinhole array, verify its fundamental optical properties on a breadboard at Goddard Space Flight Center, integrate the device onto an existing coronagraph testbed at Space Telescope Science Institute, and test its performance.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Astrophysics Research and Analysis

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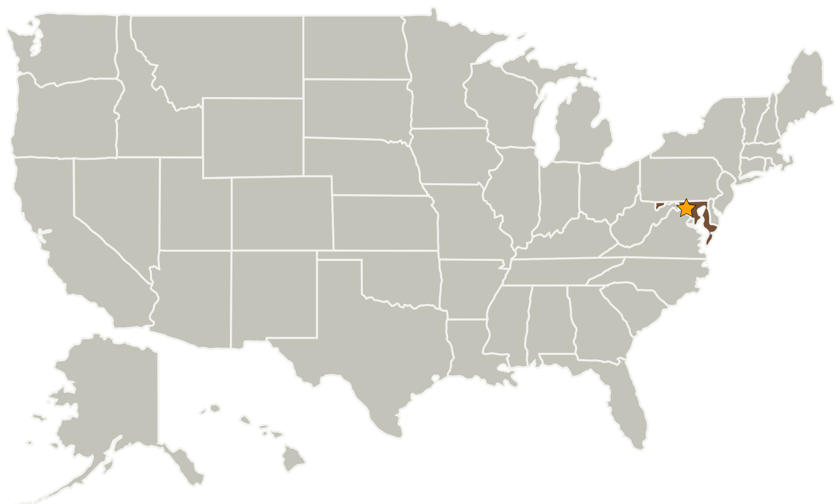
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland
Space Telescope Science Institute(STScI)	Supporting Organization	Academia	Baltimore, Maryland

Primary U.S. Work Locations
Maryland

Project Management

Program Director:

Michael A Garcia

Program Manager:

Dominic J Benford

Principal Investigator:

Neil T Zimmerman

Co-Investigators:

Remi Soummer
David T Leisawitz
Michael W Mcelwain
Qian Gong
Avram M Mandell
Tyler D Groff
Maxime J Rizzo
Brian A Hicks
Lee D Feinberg
Matthew R Bolcar

Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.1 Detectors and Focal Planes

Target Destination

Outside the Solar System